Part 3. Technical Support of the AEM Plan

3-1 Monitoring Actions

A scientifically based and informative monitoring program is central to effective AEM. The monitoring program provides the necessary data to describe previous and current conditions. Monitoring can also characterize the outcomes of the ecosystem management actions undertaken as part of the Channel Improvement Project. Importantly, the results of monitoring quantify the response of the performance measures and risk endpoints to management actions. The measured degree of success (or failure) can be used to adapt subsequent management actions if necessary. The monitoring effort is an essential component in developing the feedback between management and system response in relation to the desired condition (i.e., goals and objectives). Thus, the importance of a well-designed monitoring program cannot be overstated in the implementation of the overall AEM Process.

The degree of accuracy and precision required for each measured parameter should be specified as part of implementing the monitoring program. The data quality required for each monitored parameter can be determined in part from knowledge concerning the sensitivity of the decision-making process to the measured value. The required data quality also relates back to specification of the decision process. For example, if the management goal is an increasing population of an ESU, the corresponding monitoring program may prove less intensive (and costly) than if the goal was a population increasing at a specific desired rate (e.g., 10% per year). Conversely, a decision process will not be feasible if it critically relies on a degree of data quality that surpasses current technical capabilities or is prohibitively expensive (e.g., cost of acquiring the data exceeds funds available for management or in some cases the value of the managed resource).

USACOE' Monitoring Actions

The USACOE is implementing six monitoring actions that will help to assess the possible impacts of the Channel Improvement Project on selected physical and chemical attributes of the LCR and estuary. The USACOE has worked with the NMFS, FWS, and the states of Oregon and Washington to achieve consensus concerning the implementation of the monitoring actions, including the derivation of initial decision criteria ("trigger values") for use in adaptive management. In addition to the endpoints addressed by MA-1 through MA-6, studies are also being performed to assess the potential impacts of channel modifications on sturgeon, smelt, and Dungeness crab. Appendix D provides a detailed account of the development of the initial decision criteria for use in the AEM Process. The following paragraphs briefly describe the six USACOE' monitoring actions.

MA-1

The USACOE will maintain three hydraulic monitoring stations on the lower river. Their locations will be downstream from Astoria, Grays Bay, and Cathlamet Bay. The measured parameters include salinity, water depth, and water temperature. Physical changes resulting from channel deepening are expected to be minor and occur in proximity to the navigation channel. The proposed monitoring duration includes two years before channel deepening, two years during the construction, and three years following construction.

The MA-1 data will be analyzed to establish pre- and post-project relationships between the channel deepening and values of flow, salinity, water surface elevation, and water temperature. The purpose of MA-1 in the context of the AEM Plan is to verify levels of impact, MA-1 is essentially compliance monitoring. However, the results of MA-1 might be used to assess habitat complexity, connectivity, conveyance, and habitat opportunity.

MA-2

MA-2 will provide annual dredging volumes associated with construction and operation of the 43-foot channel. Volumes will be reported for each dredging bar (~3-mile reaches). Volumes of dredged materials will be compared to projected values.

Evaluation of dredged materials disposal in relation to projections of contract dredging volumes and disposal site capacities can contribute decision-making in relation to the AEM Plan. If dredging volumes exceed the capacity of the disposal plan, management actions might be triggered in relation to the AEM Process. This monitoring action will continue through the Project duration.

MA-3

The MA-3 will examine accretion/erosion and changes in bathymetry of the main channel in relation to the channel deepening. Surveys will be conducted annually for two years prior to construction, two years during construction, and three years after construction. Crossline surveys will be conducted within a December-February time period to coincide with the end of the dredging season. Surveys will be conducted along the navigation channel from CRM 3 to CRM 106.

MA-3 will provide information to assess physical alterations to habitat opportunity due to side-slope impacts of dredging. Adjustments to dredging are expected to occur intermittently adjacent to the navigation channel.

MA-4

MA-4 will augment estuary habitat surveys previously conducted by NMFS as part of the Anadromous Fish Evaluation Program (AFEP). The objective is to determine if changes in habitat result from the channel deepening. The surveys will assess a variety of habitat types important to juvenile salmonids (e.g., tidal marsh, swamp, flats, deep water). The survey will also address habitat complexity, connectivity, and conveyance. Habitat-specific food availability will be quantified. The use of peripheral areas by juvenile salmonids will be measured. The survey will be conducted three years after construction.

Threshold values of change (i.e., decision criteria) will be defined for each habitat type. Measures that exceed any of the decision criteria may result in adaptation to current management actions.

MA-5

The AEM Process will include the review of sediment chemistry data to evaluate the potential impacts of channel deepening on the exposure of aquatic organisms to toxic contaminants. Such reviews may be largely initiated by the observation of suspected toxicological events associated with channel improvement.

MA-6

MA-6 will provide for field surveys (April–August) to assess any Project related changes in fish stranding during outmigration. Surveys will be conducted one year before and one year after channel deepening.

If the number of stranded fish increases in relation to channel deepening, management actions might change as a result of implementing the AEM Process. Note that stranding is also being considered in relation to Section 401 Water Quality Certification requirements for the states of Oregon and Washington.

Coordinated and Integrated Monitoring Program

The scale and complexity of the lower river and estuary all but preclude the operation of a comprehensive monitoring program by any single public or private entity. Other programs that have historically collected data and information relevant to the AEM management goals and objectives can contribute to the effectiveness of monitoring in the conduct of AEM. Presumably, the data collected by the USACOE will be useful in addressing other management needs expressed for the estuary (e.g., LCREP). Thus, the implementation of the AEM Plan should provide a mechanism to share information among the various monitoring programs active in the river and estuary.

The following monitoring programs might be able to provide data and information of value to the Channel Improvement AEM Process:

CORIE

The Oregon Graduate Institute at the Oregon Health and Science University operates the CORIE, an environmental observation and forecasting system. The CORIE network (www.ccalmr.ogi.edu/CORIE/network/) includes a set of monitoring stations located throughout the Columbia River estuary. Most stations monitor water temperature, salinity, and water level. Typical sampling intervals range from 1 to 15 minutes. Most stations real-time permit access to recent data, other stations allow access only to verified archived data.

The LCR Estuary Partnership

The LCREP has developed an integrated monitoring program based largely on concerns associated with conventional pollutants, toxic contaminants, habitat degradation, and exotic species introductions.

Oregon Department of Environmental Quality

The Oregon DEQ maintains ambient water quality monitoring sites on many of the tributaries of the LCR. The program collects data describing several physical and chemical factors that appear relevant to the Channel Improvement AEM Plan, including total suspended solids, chlorophyll, color, and turbidity.

Washington Department of Ecology

The WDOE currently operates ambient water quality sites on the Washington side of the LCR. Monitoring data include total suspended solids, and certain toxic chemicals that are analyzed at irregular time intervals.

United States Geological Survey

The United States Geological Survey (USGS) operates four ambient water quality-monitoring sites on the Columbia River. These sites have provided data for long term-trend analysis for the lower river. Future monitoring may emphasize measures of primary productivity. The USGS in cooperation with the Estuary Program will monitor the concentrations of lipid-soluble organic contaminants throughout the Columbia Basin, including the lower river. The USGS Biological Resources Division is conducting an analysis of the occurrence and distribution of contaminants in biota.

United States Environmental Protection Agency

The USEPA is conducting a study of water temperatures above the Bonneville Dam. The resulting forecasting model may prove useful in understanding the sources of elevated temperatures in both the upper and lower regions of the Columbia River. The USEPA has also collected information describing the contaminants in fish flesh from samples collected above the Bonneville Dam. These results might prove useful in directing the sampling of fish tissues in the lower river.

United States Army Corps of Engineers

In addition to MA-1 through MA-6 that directly support the Channel Improvement AEM Plan, the USACOE also performs other routine and compliance monitoring (e.g., water temperature, dissolved gas), including sediment sampling for toxic contaminants.

Coordination and Integration

While recognizing the need and importance of an integrated monitoring approach to effectively managing the LCR in broader terms, the Channel Improvement AEM Plan is more narrowly focused on the potential impacts of channel improvement on the physical nature of the river and estuary. Nevertheless, the AMT could informally contribute to the coordination and integration across the various monitoring programs. Alternatively, the participating organizations could establish a centralized data management system that provides for more formal sharing and archiving of the products of the diverse monitoring activities currently underway. A centralized data management system offers the advantage of accessing various sources of data from a single location, even though the actual data might be distributed among a variety of locations. However, development of such a data management system lies currently beyond the scope of the Channel Improvement AEM Plan.

3-2 Ecosystem Evaluation Actions

The results of six proposed ecosystem evaluation actions (EEA-1 through EEA-6) can usefully serve as part of the information base that enters into the AEM Process (Figure 2.2). These evaluation actions were developed to further assist the USACOE, NMFS, and the USFWS in advancing the basic understanding of the LCR ecosystem.

In general, the evaluation actions will address indicators of the salmonid conceptual model (Appendix A)[2] and advance the knowledge base for conservation and recovery of salmonid species (e.g., Bottom et al. 2001). Several actions will provide quantitative information describing habitat parameters including bathymetric information for listed ESU, the corresponding studies will focus on tidal marsh, shallow water flats, and water column habitat. Other evaluation actions derive from concerns of sublethal effects of contaminants on growth, and survival of juvenile salmonids and their prey (e.g. Arkoosh et al. 1998).

The following paragraphs briefly outline the six EEA. Associated costs of each action could be used to characterize the value of new information produced by these studies in increasing the likely success of the proposed LCR and estuary AEM Plan.

EEA-1

EEA-1 will obtain additional data and information that describe salmonid habitats and

[2] The juvenile salmonid conceptual model developed for the Channel Improvement Project has been further elaborated into the more comprehensive Columbia River Conceptual Model (www.nwp.usace.army.mil/Pm/LCR/docs/CREConceptualmodel/START.htm).

distribution of these habitats in the estuary. This action will provide additional transects in different habitat types similar to those being conducted as part of the NOAA Fisheries AFEP. One of these transects is prescribed for Cathlamet Bay because numerical modeling completed for the CRCIP identified Cathlamet Bay as an important area to evaluate regarding potential changes in habitat availability and utilization by juvenile salmonids.

It is anticipated that these transect data would be obtained prior to construction and for an additional three years following project completion. The data will contribute to decisions regarding possible project modification if adverse impacts to the listed ESU are determined. Additionally, the data could be used to help plan future ecosystem restoration and enhance the environmental benefits associated with individual restoration projects.

EEA-2

EEA-2 will characterize coastal cutthroat trout use of tidal marsh habitat in the Columbia River estuary. Juveniles of cutthroat rear in the estuary for an extended period of time compared to other anadromous fish species. One year of data for this evaluation action has been previously collected. An additional year of pre-construction data and two years of construction period data will be collected. These data will contribute to decisions regarding possible project modification if adverse impacts to the listed ESU are determined.

EEA-3

EEA-3 includes a bank-to-bank hydrographic survey of the Columbia River estuary. This survey will provide valuable information describing the bathymetry of the estuary and shallow water-flat habitat. These kinds of data have not been collected since the mid-1980s. The results of the survey can contribute to the development and construction of future ecosystem restoration features.

EEA-4

EEA-4 addresses contaminant issues in juvenile salmonids and their prey. EEA-4 focuses on possible bioaccumulation of chemical contaminants. EEA-4 will characterize possible risks of chemical exposure associated with the potential resuspension of toxic chemicals associated with Project dredging. Pre-construction data were collected in 2002. Additional data will be collected during construction and for three years post-construction.

EEA-5

EEA-5 compliments and extends EEA-4 by examining the potential sub-lethal effects of contaminants on juvenile salmonid growth and survival. Information will be assembled to describe potential effects of accumulated chemical contaminants on physiological processes that contribute to growth. The combination of EEA-4 and EEA-5 can develop a comprehensive description of ecological risks posed by the possible mobilization of chemical contaminants as a result of CRCIP dredging.

EEA-6

EA-6, a term and condition of the NOAA Fisheries and USFWS BO, will take the form of an "Estuary Turbidity Maximum Workshop." The purpose of the workshop is to better understand the spatial and temporal variability in the location of the ETM, as well as to propose effective management actions to conserve the ETM on the basis of this understanding.

These ecosystem evaluation actions are consistent with Corps' Environmental Operating Principles and actively consider the possible environmental consequences of the Channel Improvement Project. These evaluation actions demonstrate an attempt to seek a balance between the proposed channel improvement project and the environmental integrity of the Columbia River estuary through designing mutually beneficial economic and environmental solutions. These ecosystem evaluation actions reflect an effort by the Corps Portland District, the Sponsor Ports, NOAA Fisheries, and the USFWS to develop an integrated scientific, economic and social knowledge base that supports a greater understanding of the environment, particularly as it relates to juvenile salmonids of listed ESUs, and the CRCIP. The national importance of these ESUs justifies the evaluation actions described for this project. Management emphasis on recovery of these ESUs is shifting from above Bonneville Dam to the lower Columbia River and estuary.

Data produced by these actions will be collated and provided to the AMT to (1) determine the possible need for alteration of the Project actions (i.e., dredging); and (2) assess the value of information provided by the actions in relation to management and decision-making. Importantly, the results of these studies may assist in the analysis and interpretation of monitoring data. These studies might also provide critical information for the development and implementation of environmental/ecological models used in support of the AEM Process.

3-3 Identification of Models

Both conceptual and operational models will be necessary for successful management within an AEM framework. Conceptual models can importantly assist in the design of the AEM Plan. Operational models can provide quantitative forecasts of the likely impacts of channel deepening in terms of the selected performance measures and risk endpoints. Operational models can also estimate the expected effects of ecosystem management on juvenile salmonid habitat, habitat opportunity, and associated salmonid growth, survival, and ocean entry.

Conceptual Models

Within the AEM and risk-based framework, conceptual models should be developed in relation to proposed management objectives as an initial step in making the decision-support framework operational. A conceptual model essentially describes in schematic shorthand the nature and content of the management process. The model attempts to reduce ecological complexity by focusing on selected ecosystem attributes that are essential in addressing a specific management challenge. This feature of the model helps to define the information that must be obtained and organized to describe the general characteristics and desired conditions of the managed ecosystem. The model also attempts to identify key cause-effect relationships that provide a basis for implementing models used forecast the outcomes of management actions. This aspect of the model depicts a qualitative understanding of interactions among system components that are vital to understanding and management. The conceptual model thereby assists in identifying the necessary and appropriate data (e.g., monitoring) and tools (e.g., models) needed to examine the proposed Project within the AEM decision framework i.e., Figures 1.1 and 2.2). Appendix A presents conceptual models developed to support the LCR and estuary AEM Process. Table 3.1 indicates how the proposed management actions may provide information for various aspects of the conceptual models.

Operational and Forecasting Models

Management challenges in the LCR and estuary involve complex, imperfectly understood ecological systems described by incomplete data. These circumstances suggest that environmental models will be increasingly relied upon to assist management and decision-making. As indicated in the overall management framework (Figure 1.1), environmental models can be used to (1) describe and understand the current conditions of the resources of concern, (2) explain historical trends, and (3) forecast the outcomes of management actions. Implementing the AEM framework requires the identification of specific environmental models (e.g., hydrologic, ecological, meteorological, chemical) that can be used to address the resources of concern in the context of the goals, objectives, and the decision process. Key criteria for selecting models are the operational (i.e., mathematical, statistical) relationships between factors affected by management decisions, for example, salinity changes and the assessment endpoints or performance measures selected to evaluate resources in relation to the desired conditions. The models must be capable of translating management actions into the expected corresponding changes in the values of the endpoints and measures used in decision-making (Pastorok et al. 2002).

The first step is to comprehensively search among existing models to identify those that are currently used or that can be either directly applied or that might be relevant following an acceptable level of effort in adapting the models. In some instances, new models might have to be developed. If so, the schedule for implementing the overall AEM framework must accommodate the time required for model development, testing, and application.

Application of the models clearly requires values of all the model input parameters. Ideally, the values would be derived using site-specific data and information. In practice, the parameter values will likely include site-specific data, estimates derived for similar applications, and in some instances, values based on best professional judgment. In all cases, the sources and estimation of the parameter values should be documented. Uncertainties (e.g., bias, imprecision) associated with each parameter should also be quantified or otherwise described as part of the process.

Table 3.1. Integration of LCR ecosystem conceptual model, monitoring, and ecosystem evaluation actions

	Conceptual Model Pathway and Indicators Addressed					
AEM Feature	**Habitat Processes**	**Habitat Types**	**Primary Productivity**	**Food Web**	**Growth**	**Survival**
MA-1	Salinity				Habitat connectivity, conveyance, habitat opportunity	Salinity, temperature
MA-2	Suspended sediments, bedload					Suspended solids
MA-3	Bathymetry (main channel)					
MA-4	Suspended sediments, turbidity	Tidal marsh, tidal flats, swamp	Benthic algae	Macroinvertebrates, insects, suspension/deposit feeders, resident macrodetritus	Habitat complexity, feeding opportunity, food availability, refugia	Suspended solids, turbidity, predation
MA-5						Contaminants
MA-6						Stranding
EEA-1		Tidal marsh, swamp, flats, main channel				
EEA-2		Tidal marsh, tidal flats, swamp, main channel				
EEA-3	Bathymetry	Shallow water- flats habitat				
EEA-4						Contaminants
EEA-5						Contaminants
EEA-6	Salinity		Phytoplankton			Salinity, turbidity

The results of model calculations should be evaluated to ensure that they are of proper format (e.g., units) to contribute directly to the management and decision-making process. The model outputs should correspond as closely as possible to the selected assessment endpoints or performance measures used to define the desired conditions (system state).

3-4 Identifying, Characterizing, and Addressing Uncertainties

As formulated, the proposed AEM Plan for the Channel Improvement Project is an example of risk-based decision-making or decision making under uncertainty. Risk-based decision-making takes into account the uncertainties that arise from natural variability and imperfect knowledge. Uncertainty can confound the decision-making process by eroding confidence in accurately selecting among alternative management actions. Managers can minimize the effect of uncertainty by recognizing the presence of natural variability in ecosystems and defining management objectives probabilistically, as risk endpoints. Analysis of risk based on ecological forecasting and the errors inherent in these forecasts establishes bounds on uncertainty and provides additional information that can be incorporated into decisions. This introduces a set of probabilistic tools for characterizing uncertainty, describing confidence bounds, and applying this information in decision-making.

Application of a risk-based approach to ecosystem management draws on experience in two related areas. First, concepts of uncertainty and risk and the probabilistic tools for their analysis have deep roots in engineering practice. The application of these tools to water management by the USACOE (National Research Council 2000) translates directly to the management of the channel deepening. Second, concepts of mapping the response of organisms and ecosystems to environmental stressors form the basis for evaluating risks of toxic substances released into the environment (USEPA 1998). The approach developed to direct the cleanup of Superfund hazardous waste sites provides a model for applying conceptual models, performance measures and environmental monitoring to the more general problem of ecosystem management. Although the proposed AEM Process does not emphasize risks posed by toxic chemicals, the overall USEPA framework for risk assessment has been usefully adapted to management challenges involving physical degradation of large river ecosystems [e.g., Upper Mississippi River Navigation Feasibility Study (UMRNFS)].

Various sources of uncertainty will influence management and decision-making in this complex river and estuary. Sources of uncertainty fall into three broadly recognized categories: natural variability, knowledge uncertainty, and decision model uncertainty. Uncertainty associated with each of these categories has different implications for decision-making.

Natural variability refers to the inhomogeneous properties of natural materials, such as soils and sediments, and the range and relative frequency of events, such as rainfall or stream flow. This source of uncertainty relates to the unknown "states of nature" that must be taken into account in decision-making under uncertainty. Often, stochastic models provide descriptions of these variable characteristics for decision-making purposes. Gathering additional better information cannot reduce natural variability, although the accuracy of the related stochastic models might be improved

Knowledge uncertainty reflects deficiencies in understanding of ecosystems and factors that affect them. If knowledge uncertainty is high, either because the data are poor or because the models are inaccurate, then it may not be possible to distinguish the effect of one management alternative from another with an acceptable degree of certainty. In principle, gathering more information and better data can reduce this uncertainty. Knowledge uncertainty also reflects errors in the data available to describe ecosystem structures and processes. Bias and imprecision can result from poorly designed or improperly executed monitoring programs. Sample collection, data analysis, data management and reporting can all introduce errors. Importantly, uncertainties introduced as part of monitoring can impair the decision-making process. Conversely, the management and decision-making process can result in the refinement of monitoring programs to reduce knowledge uncertainties and improve the overall effectiveness of the decision-making process.

Knowledge uncertainty can also introduce errors in the models used to interpret data and make predictions. Hydrologic and ecological models can be used extensively to project the expected outcomes of channel improvement on estuarine resources and performance measures. To the extent that the models are simplified and imperfect representations of complex hydrologic and ecological processes, bias and imprecision can enter into decision-making based on results from these models. Assumptions concerning basic model structure, as well as the quantification of initial conditions and estimation of model parameter values, can also introduce uncertainties into the use of models within the general decision-making framework (Figure 1.1).

Uncertainties associated with management and decision-making should be identified and characterized. The implications of these uncertainties on projected decision outcomes and risks should be quantified. The expected effects of channel improvement on achieving desired ecosystem conditions or incurring risks of adverse impacts will be estimated using quantitative (qualitative where necessary) relationships (stress-response functions) between the variables manipulated through management actions (e.g., water levels, salinities) and the selected performance measures and assessment endpoints. Each of the manipulated variables is a source of uncertainty, each of the functional relationships, whether a regression model or a complex process-based simulation, can also introduce uncertainty. These uncertainties, along with natural variability should be described, quantified, and where possible, propagated through the calculations used to estimate decision outcomes and risk.

Numerical methods are available for relating uncertain outcomes to uncertain input values as part of the risk estimation process. Results of these uncertainty analyses can be used to identify critical new data needed to refine the assessment and increase the effectiveness of the decision-making process. These analyses should be performed for the functional relationships used to estimate risk and include as many of the input and outcomes as practical and permitted by the assessment models and data.